

Mucous Envelope Formation in Two Species of Hawaiian Parrotfishes (Genus *Scarus*)¹

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ABSTRACT: Some parrotfishes have developed a unique capacity to form a mucous envelope at night. *Scarus dubius* and *S. perspicillatus* are two Hawaiian species that exhibit envelope-building behavior. Laboratory experiments indicate that envelope formation is promoted by darkness, and is inhibited by constant light. The completed envelope is a transparent, mucous cocoon surrounding the fish. A mass of glandular tissue was found in the buccal cavity of *S. dubius* and *S. perspicillatus*. It is suggested that this tissue is the envelope-producing gland.

THE PARROTFISHES are common inhabitants of tropical coral reefs. Several species inhabiting Bermudan reefs have been noted for their ability to form a large mucous envelope at night (Winn, 1955; Winn and Bardach, 1959, 1960). The structure was described as a "thin transparent and gelatinous mucoïd substance which starts as a fold at the mouth and progresses backwards in folds to surround the body" (Winn, 1955). It was suggested that the envelope functions as a protective device which serves to reduce predation by nocturnal organisms (Winn and Bardach, 1959).

This paper describes envelope formation in two species of Hawaiian parrotfishes, *Scarus dubius* and *S. perspicillatus*. The study concerns envelope formation under light and dark conditions, and provides a description of the location and general morphology of the mucus-producing gland.

MATERIALS AND METHODS

Laboratory specimens were trapped or netted on the coral reefs in Kaneohe Bay, Oahu. The fish were maintained in wire cages that were suspended in the saltwater lagoon next to the laboratory. Only vigorous and apparently healthy individuals were used for the experiments.

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The first laboratory tests examined the effects of light and dark on mucous-envelope formation. Six 10-gallon aquaria were equipped with sub-sand filters and prepared with a 4- to 5-cm substrate of coarse sand. Three of these aquaria were maintained in constant artificial light, with two 25-watt incandescent lamps positioned 7 cm above the water surface. These aquaria were isolated on all sides by cardboard shields, and observations were made through a small, movable viewing port.

Three similar aquaria were provided with a light-tight covering of black cardboard. These aquaria had the viewing ports covered by red plastic filters to prevent any interference with envelope building by the external lighting. A one-cell penlight was used to facilitate visual identification of the mucous envelope.

One to four individuals were introduced to each aquarium for trials that had a maximum duration of 24 hours. All observations occurred at 30-minute intervals, and the presence or absence of a mucous envelope was recorded.

In a second experiment, the behavior of *S. dubius* was recorded before, during, and after envelope formation. One fish was placed in each 10-gallon aquarium and the room lights were turned off. Observations were made at 15-minute intervals with the aid of a one-cell penlight. The location, posture, and progress in envelope building were recorded for each fish. The lights were turned on after envelope formation was complete, and the behavior and external respiratory rate of all specimens were recorded.

Insoluble carmine would adhere to the outer

surface of the envelope, and this dye was used to define clearly the structure and extent of the completed envelope.

Specimens of *S. perspicillatus* and *S. dubius* were dissected to examine tissues localized as mucus-producing areas. These areas were identified by their reaction to toluidine blue, a meta-chromatic stain which renders such mucus-producing areas a deep red violet (Lillie, 1965; Thompson and Hunt, 1966).

RESULTS

Field observations recorded while obtaining laboratory specimens indicated that at high tide large schools of parrotfishes were found on the shallow reef flats. At low tide these same schools were found in deeper water near the reef edge. Fewer parrotfishes were observed on the reef flat as daylight intensities decreased. The schools dispersed, and it was confirmed that these fish entered holes and crevices on the reef edge during the night (Winn, 1955; Schroeder and Stark, 1964). Observations of specimens that were kept in the wire cages in the lagoon indicated that the mucous envelope was formed only at night.

In the laboratory, envelope formation was completely inhibited for at least 24 hours by constant light. A total of 29 individuals, both *S. dubius* and *S. perspicillatus*, did not form envelopes during these experiments.

Darkness promoted envelope building in 22 of 30 individuals tested. Both envelope formation and its inhibition occurred with the same frequency in the two species. Complete envelope formation occurred from 30 to 240 minutes after the fish were placed in the darkened

aquaria. The average envelope-building times for *S. dubius* and *S. perspicillatus* were 71 minutes and 69 minutes respectively. No individual in a darkened aquarium remained inside its mucous envelope for the complete 24-hour test period. The average emergence time in the laboratory for both species was 120 minutes after envelope formation.

Envelope formation was induced in 54 to 88 percent of the trials using darkened aquaria. Envelope building started when a fish was immobile and resting on the bottom in an upright position. These fish were always supported on at least one side by a rock or the aquarium wall. The process of envelope formation and the completed envelope appeared identical with those described by Winn (1955). The envelope developed first at the anterior end of the fish and progressed backward in folds to surround the body. The completed envelope appeared as a transparent, gelatinous cocoon surrounding the fish. A small hole, 1 to 2 cm wide, was observed at the posterior end of all envelopes. A water soluble dye indicated that this hole functioned as an escape-duct for respiratory water forced out of the buccal cavity. Fine debris adhered to the envelope's exterior and the outline was thus more clearly defined. However, this latter aspect conveyed the impression that the structure was very thin and fragile. The fish remained quiescent within the envelope, and no immediate reaction was noted when the room lights were turned on. Swimming movements began 3 to 5 minutes later.

The opercular movement rate was counted in three individuals before, during, and after envelope formation. This rate was reduced 46 percent in both species after complete envelope formation.

Carmine particles sprinkled on the surface of the envelope rendered it suitable for color photography. Carmine was also injected into an envelope formed by a 20-cm specimen. The particles remained suspended 2 to 8 cm from the body of the fish, indicating that the structure was 6 cm thick in some areas.

Examination of stained tissues and dissection of individual fish revealed a mass of glandular tissue in the buccal cavity of both species. Figure 1 illustrates the glandular mass in a 4-cm speci-

TABLE 1
RELATIONSHIP OF LIGHT AND DARKNESS TO MUCOUS-
ENVELOPE FORMATION BY *Scarus dubius*
AND *S. perspicillatus*

	MUCOUS ENVELOPE		TOTAL
	FORMED (no. specimens)	NOT FORMED (no. specimens)	
Light	0	29	29
Dark	22	8	30



FIG. 1. The large mass posterior to the gills is the major glandular concentration in the buccal cavity of *Scarus dubius*. Other glandular areas are ventral to the gills and on the inner opercular surface (top center and right).

men of *S. dubius*. The major portion of the gland was located at the rear of the opercular cavity, posterior to the gills. Glandular material was also noted on the inner opercular surface and on those tissues ventral and medial to the gills.

Similar glandular material was not present in fish that did not form mucous envelopes. The labrid *Labroides phthiophagus* was observed forming a mucous envelope in an aquarium. Specimens were examined and a mass of glandular material was located in the buccal cavity. This tissue was distributed in a branched arrangement on the inner surface of the operculum. There was no massive concentration of glandular material posterior to the gills in *L. phthiophagus*.

DISCUSSION

The behavior of parrotfish schools on Hawaiian reefs was similar to that described by Winn (1955) for Bermudan parrotfishes. *Scarus dubius* and *S. perspicillatus* were not observed forming mucous envelopes during the day. Apparently both school dispersal and envelope formation are responses to decreasing light intensity.

These experiments indicated that constant light inhibits envelope formation in these two species for at least 24 hours. Darkness promoted envelope formation at any time of day in the majority of individuals tested. Envelope

formation might be inhibited by the short exposures to a penlight at 30-minute intervals, thus accounting for the eight individuals failing to form envelopes in darkened aquaria. These short exposures to red light may also be responsible for the extended times (30 to 240 minutes) necessary to complete envelope building. No tests were conducted on light quality or the effect of wavelength on envelope building. It is quite possible that the red plastic filters used in these tests were inadequate, and could transmit wavelengths that inhibit envelope formation in some individuals. The average 120-minute emergence time may also represent a premature response caused by the observations every 30 minutes.

The fish were immobile within the envelopes, and their only activity was slow opercular movement. Respiratory water was forced out of the small hole at the rear of the envelope. Carmine particles injected into the envelope revealed that the structure was quite thick in some areas, an observation which differs from Winn's (1955) description of the envelope as a thin, transparent membrane. Particulate matter adhering to the envelope's surface gives the illusion of a thin membrane.

The glandular tissue concentrated in the opercular chambers of *S. dubius* and *S. perspicillatus* may be the source for the copious amounts of mucus necessary in envelope formation. Similar tissue concentrations were found in the opercular chambers of *Labroides phthiophagus*, another envelope-forming species.

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